AN INVESTIGATION OF EVAPORATION OVER FREE SURFACES OF WATER IN INLAND SOUTH AFRICA.

By A. H. Wallis, C.E.

Having constructed several dams, of capacities varying from 5 millions to 45 million gallons, in the Bechuanaland Protectorate, and noticing the great losses which occurred through evaporation, the author has gone into this question with a view to ascertaining whether some simple method cannot be arrived at to guide the engineer in making provision for such losses.

Through the courtesy of Mr. Innes, the Union Astronomer, Father Goetz of Bulawayo, and Dr. Sutton of Kimberley, the author was afforded an opportunity of inspecting the evaporation gauges at the Union Observatory, the Bulawayo Observatory, and the Kenilworth gauge near Kimberley, as well as, through the courtesy of Mr. Lynch, the Manager of the Kimberley Waterworks, Ltd., the gauge at Newton, Kimberley. The following considerations have been based on the records of the first two of these gauges.

Some of these have already been described in scientific journals; their particulars may be summarised as follows:

(1) Union Observatory, Johannesburg; latitude 26° 11′ S., longitude 28° 45′ E., altitude 5924 ft. Square tank about 6 ft. Observations taken by a float and a graduated arc. The gauge is on the top of a hill surrounded by a few trees, which probably interfere with the free movement of the wind. The Observatory building also casts a shadow over the gauge, which might lessen the observed evaporation after 5 p.m.

(2) The Observatory, Bulawayo; latitude 20° 09′ 1″ S., longitude 28° 36′ 3″ E., altitude 4460 ft. above sea-level. Gauge is composed of a circular tank 7 ft. in diameter on the top of a hill well exposed to wind conditions. Records taken from a float on a circular arc.

(3) Dr. Sutton's tank, Kenilworth, Kimberley; latitude 28° 42′ S., longitude 24° 47′ E., altitude about 4000 ft. above sea-level. Observations are taken from a 6-ft. tank built into the ground, from which a pipe is led off into a closed room, where a float records by clockwork. The tank is situated in an area which is sheltered by trees on all sides, and it is thought that the conditions are not ideal for evaporation purposes.

(4) Newton, Kimberley. Observations are taken from a tank about 4 ft. square built into the ground on the top of a hill exposed to every condition, with no surrounding trees. The observations are taken by means of a hook gauge, which permits of readings being directly observed to one thousandth

of an inch. Unfortunately there are no hygrometric observations taken at this gauge.

It will be seen that, although the conditions attending these gauges are dissimilar in several important respects, where the hygrometric conditions are observed in the vicinity of the gauges the evaporation will naturally bear relationship to the observed relative humidity at each.

The author has compiled the information for Johannesburg, Newton, Kimberley, Bulawayo, for five years ending December 31, 1917.

He has unfortunately been unable to secure the records of Dr. Sutton, Kimberley, for this period, and they are therefore not available for comparative purposes in this paper. The records of Newton, Kimberley, can only be looked upon in the light of interesting figures, as owing to there being no psychrometric data available, comparison cannot be drawn between relative humidity and evaporation, which latter is higher; and it can be concluded that, owing to the exposed position of the gauge, the relative humidity will be exceedingly low.

Upon proceeding to plot as a graph the recorded evaporation compared with the recorded relative humidity, the author found that when the evaporation increased, the relative humidity decreased.

Bearing in mind the fact that evaporation does not vary as the relative humidity, he found that a consistent relation obtained in the graph, between the difference of relative humidity and saturation and the recorded evaporation. That is to say E. varied as 100–H. This factor the author has hereinafter referred to as the "deficiency factor." Attention is now invited to the records of Bulawayo and Johannesburg, as shown on the attached series of tabulated statements, from which it will be seen that the mean annual temperature of each place varies considerably with the annual temperature, as follows:

YEAR.	BULAWAYO. LAT. 20° 09′ 15″ S.		JOHANNESBURG. LAT. 26° 11′ S.	
	MEAN TEMP. $\frac{\text{Max.} + \text{Min.}}{2}$	DIFFERENCE FROM MEAN OF 5 YEARS.	MEAN TEMP. $\frac{\text{Max.} + \text{Min.}}{2}$	DIFFERENCE FROM MEAN OF 5 YEARS.
1913	67·1°	+ ·54 above	60·27°	+ ·498 above
1914	67·1°	+ ·54 ,,	60·74°	+ ·968 ,,
1915	65·9°	− 1·20 below	59·53°	− ·242 below
1916	66·5°	− 0·06 ,,	60·24°	+ ·468 above
1917	66·2	− 0·36 ,,	58·08	− 1·692 below
MEAN OF FIVE YEARS	66·56	+ 1·08 − 1·62	59·772	+ 1·934 − 1·934

The annexed tables show the evaporation in decimals of an inch divided by the "deficiency factor," from which it will be seen that the mean evaporation per annum for five years at Bulawayo is 2·081389 inches per 1 per cent. of deficiency per annum, or ·0057024 inches per 1 per cent. of deficiency per diem; whilst for Johannesburg the same figures result in 1·460397 inches and·0040009 per annum and per diem respectively, whilst the mean annual temperature $\frac{(\text{max.}+\text{min.})}{2}$ were 67·1° and 59·7° respectively.

It will be borne in mind also that Bulawayo is 20° 09′ 1″ S. latitude, and Johannesburg is 26° 11′ S.—a difference of 6·2° of latitude; that, assuming all other conditions to be equal, an allowance must be provided for the difference of the intensity of the sun's rays in latitude.

The Smithsonian tables give factors for the relative intensity of solar radiation for the Northern Hemisphere, and the author is informed by Father Goetz at Bulawayo that the same factors can be applied relatively to the Southern Hemisphere.

The factors for the year are as follows: For 20° latitude, 0·289; for 30° latitude, 0·268.

But yet another correction has to be applied, and that is the "hours of sun above the horizon."

Dr. Sutton, in a communication to the 'Agricultural Journal of the Union of South Africa,' gave relative evaporations with sunshine observations from a Campbell-Stokes sunshine recorder, and there appeared to be no actual relation between sunshine and evaporation—a result which can only be expected, inasmuch as a largely increased evaporation must naturally take place during cloudy weather, when the sun is obscured. In fact, many observers state that evaporation takes place to a greater extent when clouds are in the sky, for the simple reason that the heat rays are reflected by clouds, causing the actual temperature to be greater; but it is apparent that the sun is primarily the cause of all heat, and therefore primarily the cause of all evaporation, and from the moment the sun rises above the horizon until it sets evaporation must be going on. Therefore the hours of sun above the horizon must form an important consideration.

Most people are apt to forget that the thermometer is not an index of *quantity* of heat, since it only registers the momentary effect of heat; hence the time factor has to be brought in, *i. e.* the hours of sun above the horizons and this consideration bears largely on the apparent difference between the evaporation of, say, January and June. At Cape Town, according to the hours of daylight in 'Letts' Diary,' there are in January approximately 14 hours of daylight per diem, or 445 hours of daylight per month, whilst in June there are 9·9 hours and 299 hours respectively for the same periods; and at Johannesburg similar figures for January and June are 13·4 and 10·6 hours per diem, or 418 hours as against 317 hours per month.

Although the factors on the annexed tables give the mean daily evaporation in inches, and although the author concludes as per the preceding paragraph that the evaporation is dependent upon the hours of sunlight, the fact must not be lost sight of that a certain amount of evaporation takes place during the night, owing to terrestrial radiation.

Dr. Sutton has shown that at Kenilworth approximately one-third of the total daily evaporation takes place during the hours of the night.

One point must not be lost sight of, and that is that these results have been based on observations taken at 8.30 a.m. daily, and that the recorded evaporation is that of the whole twenty-four hours of each day. It is quite reasonable to suppose that the relative humidity varies during each hour of the day, so that in the event of records being taken by subsequent observers the E. per deficiency factor may be found to be lower than in these conclusions. The results can therefore only be regarded as relative.

The author has annexed a table based upon Dr. Sutton's figures showing the mean annual evaporation for each hour of the twenty-four at Kimberley, and as an additional proof that evaporation follows closely upon the 'deficiency factor' of humidity the lines of this factor per hour are shown.

In presenting this paper to the Society the author has refrained from evolving a formula, being content to show the recorded evaporation at gauges that he has seen and considers to be the best available ones existing.

He trusts that he has made it clear.

It is to be hoped that meteorologists and engineers will follow up by further research on the lines above indicated, with the view to the establishment of a formula which will not be only suitable to Africa, but to the whole world.

EVAPORATION · THE OBSERVATORY · BULAWAYO·

LAT. 20° 09·1.S LONG. 28° 36·3.E ALT. 4460 FT

SUMMARY OF OBSERVATIONS FOR PERIOD OF FIVE YEARS.

YEAR	EVAPORATION TOTAL INCHES PER ANNUM.	WIND MEAN MILES PER DIEM.	MEAN ANNUAL TEMPERATURE $\frac{\text{max}+\text{min}}{2}$ Degrees. F.	MEAN ANNUAL RELATIVE HUMIDITY. H %	MEAN ANNUAL DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN ANNUAL EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY
1913.	83·30.	171·6.	67·1.	59	41	2·031707.	·0055663.
1914.	76·47.	192·0.	67·1	64.	36.	2·124167.	·0058197.
1915.	66·32	176·4.	65·9.	69.	31.	2·139355.	·0058612.
1916.	76·62.	179·1.	66·5.	63.	37.	2·070808.	·0056579.
1917.	71·94.	180·5	66·2.	65.	35.	2·055429.	·0056313
MEAN OF FIVE YEARS	74·93.	179·92.	66·56.	64.	36.	2·081389.	·0057024.

TABLE 1.

EVAPORATION · THE OBSERVATORY BULAWAYO ·

LAT. 20° 09·1.S. LONG. 28°36·3.E ALT. 4460FT

OBSERVATIONS FOR 1913.

1913.	EVAPORATION INCHES.	WIND MEAN MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{Max + min}}{2}$ Degrees. F.	MEAN DAILY RELATIVE HUMIDITY H %	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES per 1% DEFICIENCY OF RELATIVE HUMIDITY
JAN	8·94	183·9	73·7	60	40	·223500	·0072096
FEB	5·45	178·5	72·1	79	21	·259524	·0092687
MAR.	6·64	185·4	68·7	69	31	·214193	0069094
APR.	5·04	145·2	66·8	76	24	·210000	·0070000
MAY.	5·38	145·6	62·1	66	34	·158235	0051043
JUN.	4·36	155·5	55·5	63	37	·117838	·0039279
JUL.	4·39	109·7	58·4	50	50	·087800	·0028323
AUG	5·95	172·1	62·0	50	50	·119000	0038387
SEP.	8·89	226·1	67·2	50	50	·177800	·0059267
OCT	9·65	216·0	71·8	50	50	·193000	·0062258
NOV.	7·99	176·8	70·1	59	41	·194878	·0064859
DEC.	10·62	165·8	76·0	45	55	·193091	·0062287
MEAN.	..	171·6	67·1	59	41	--	·0055663
TOTAL.	83·30	...	-	-	-	2·031707	--

TABLE 2.

EVAPORATION · THE OBSERVATORY · BULAWAYO ·

LAT 20° 09·1.S LONG. 28°36·3.E. ALT. 4460FT

OBSERVATIONS FOR 1914.

1914.	EVAPORATION INCHES.	WIND MEAN MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{Max + min}}{2}$ Degrees. F.	MEAN DAILY RELATIVE HUMIDITY H%.	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN	7·94	168·3	73·9	65.	35	·226857	·0073172
FEB	4·81	192 1	69·6	86	14.	·343571	·0122704
MAR	6·64	193·1	70·1	67	33	·201212	·0064907
APR	6·38	176·4	69·3	68	32	·199375	·0066458
MAY	5·03	149·7	62·3	69	31	·162258	·0052341
JUN	4·90	181·0	58·8	52	48	·091667	·0030556
JUL	3·63	170·5	55·5	66	34	·106765	·0034440
AUG	5·17	218·8	59·4	65	35	·147714	·0047650
SEP.	8·97	210·3	70·5	48	52	172500	·0057500
OCT	10·75	257·1	74·2	45	55	·195954	·0063050
NOV	8·17	216·2	73·0	53	47	·173829	·0047943
DEC	4·58	150·8	71·4	83	17	·269412	·0086917
MEAN	-	192·0	67·1	64	36	.	0058197
TOTAL.	76·47	--	..			2·124167	--

TABLE 3.

EVAPORATION · THE OBSERVATORY BULAWAYO ·

LAT. 20° 09·1.S. LONG. 28°36·3.E. ALT 4460 FT

OBSERVATIONS FOR 1915

1915	EVAPORATION INCHES.	WIND MEAN MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{Max + min}}{2}$ Degrees. F.	MEAN DAILY RELATIVE HUMIDITY H %	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	4·63	125·7	70·9	92	08	578750	·0186694
FEB.	4·46	153·1	68·5	87	13	343077	·0122528
MAR	4·35	164·1	66·1	80	20	·217500	·0070161
APR	5·30	123·7	66·4	72	28	189286	·0063095
MAY	3·90	191·3	59·9	77	23	169565	·0054699
JUN	3·69	166·3	57·0	71	29	127241	·0042414
JUL	3·92	166·5	61·2	71	29	135172	0043604
AUG	5·44	195·5	60·8	62	38	143158	·0046180
SEP	6·44	236·1	66·3	54	46	140000	0046667
OCT	8·39	246·7	70·9	50	50	167800	·0054129
NOV	7·47	202·8	72·1	53	47	·158936	0052979
DEC.	8·33	202·1	72·3	58	42	·198333	·0063978
MEAN.	-	176·4	65·8	69	31	--	0058612
TOTAL.	66·32	--	-	--		2·139355	-

TABLE 4.

EVAPORATION · THE OBSERVATORY BULAWAYO ·

LAT. 20° 09·1.S. LONG. 28°36·3.E. ALT. 4460 FT.

OBSERVATIONS FOR 1916.

1916.	EVAPORATION INCHES.	WIND MEAN MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{Max + Min.}}{2}$ Degrees. F.	MEAN DAILY RELATIVE HUMIDITY H %	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	8·23	171·0	70·9	76	24	·342917	·0110619
FEB.	7·74	161·1	73·5	58	42	·184286	·0063546
MAR.	6·75	173·2	70·2	72	28	·241071	·0077765
APR.	5·06	160·5	65·1	70	30	·168666	·0056222
MAY.	4·93	145·2	59·7	66	34	·145000	·0046774
JUN.	3·79	142·7	58·0	60	40	·094500	·0031500
JUL.	4·63	178·8	58·3	62	38	·121842	·0039304
AUG.	5·01	191·0	59·6	50	50	·100200	·0032323
SEP.	7·48	202·9	67·5	44	56	·133571	·0044524
OCT.	9·94	237·2	73·7	50	50	·198800	·0064129
NOV.	7·38	207·9	71·2	63	37	·199459	·0066486
DEC.	5·68	173·1	69·9	80	20	·284000	·0091613
MEAN.		179·1	66·5	63	37		·0056579
TOTAL.	76·62					2·070808	

TABLE 5.

EVAPORATION · THE OBSERVATORY BULAWAYO ·

LAT. 20° 09·1.S. LONG. 28°36·3.E. ALT 4460FT.

OBSERVATIONS FOR 1917.

1917.	EVAPORATION INCHES.	WIND MEAN MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{Max \& Min.}}{2}$ Degrees F.	MEAN DAILY RELATIVE HUMIDITY H%	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	6·42	178·0	69·6	72	28	·229286	·0073963
FEB.	6·49	176·0	70·9	66	34	·190882	·0068172
MAR.	6·21	207·4	68·9	69	31	·200323	·0064640
APR.	5·19	150·6	65·9	73	27	·192222	·0064074
MAY.	3·83	136·8	60·7	75	25	·153200	·0049419
JUN.	4·08	111·4	59·1	57	43	·094884	·0031628
JUL.	4·14	127·7	57·3	61	39	·106154	·0034243
AUG.	5·32	219·4	60·7	66	34	·156470	·0050474
SEP.	7·37	241·5	66·6	64	36	·204722	·0068240
OCT.	9·51	215·1	73·8	45	55	·172909	·0055777
NOV.	8·01	204·8	72·8	63	37	·216486	·0072162
DEC.	5·17	199·2	68·4	83	17	·304118	·0098103
MEAN.		180·5	66·2	65	35		·0056313
TOTAL	71·94					2·055429	

Table 6.

EVAPORATION · UNION OBSERVATORY · JOHANNESBURG ·

LAT. 26°·11.6. LONG. 28°4·5.E. ALT. 5924 FT.

SUMMARY OF OBSERVATIONS FOR PERIOD OF FIVE YEARS.

YEAR.	EVAPORATION TOTAL INCHES PER ANNUM.	WIND MEAN MILES PER DIEM.	MEAN ANNUAL TEMPERATURE $\frac{\text{max + min}}{2}$ Degrees. F.	MEAN ANNUAL RELATIVE HUMIDITY H%	MEAN ANNUAL DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN ANNUAL EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
1913.	68·55.	317·2.	60·27.	56·28.	43·72	1·567932.	·0042957.
1914	66·12	262·2	60·74.	58·18	41·82	1·581062.	·0043317
1915	55·60.	277·4	59·53.	60·00	40·00	1·390000.	0038082
1916	61·76.	279·6	60·24.	52·53	47·47	1·301032	·0035644.
1917.	54·04.	274·0.	58·08.	63·03.	36·97.	1·461726.	·0040047.
MEAN OF FIVE YEARS	61·214	282·08	59·772	58·004.	41·996.	1·460397.	·0040009.

Table 7.

EVAPORATION· UNION OBSERVATORY·JOHANNESBURG·

LAT 26° 11.S LONG 28° 4·5.E., ALT. 5924 FT.

OBSERVATIONS FOR 1913.

1913.	EVAPORATION INCHES.	WIND MEAN MILES per diem	MEAN TEMPERATURE $\frac{\text{max}+\text{min}}{2}$ DEGREES. F	MEAN DAILY RELATIVE HUMIDITY. H %	MEAN DAILY DEFICIENCY of RELATIVE HUMIDITY 100−H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	6·46	331·2	66·1	65·8	34·2	·188889	·0060932
FEB.	5·39	292·8	65·9	72·0	28·0	·192500	·0068750
MAR	5 17	276·0	62·2	71·8	28·2	·183333	·0059139
APR	4·00	244·8	60·2	69·6	30·4	131578	·0043859
MAY.	4·43	319·2	54·6	48·4	51·6	·085853	0027694
JUN.	3·91	312·0	51·1	48·1	51·9	075337	·0025112
JUL	4·72	324·0	53·8	38·4	61·6	·076623	·0024717
AUG.	5·62	352·8	56·0	43·6	56·4	·099645	·0032143
SEP.	6·54	355·2	58·3	41·3	58·7	111414	0037138
OCT	7·18	357·6	61·6	56·5	43·5	·165057	·0053244
NOV.	6·76	290·4	65·0	61·1	38·9	·173739	·0057926
DEC	8·37	350·4	68·4	58·8	41·2	·203155	·0065534.
MEAN.	..	317·2	60·27	56·28	43·72	....	·0042957.
TOTAL	68·55	.	..	..	..	1·567932	....

TABLE 8.

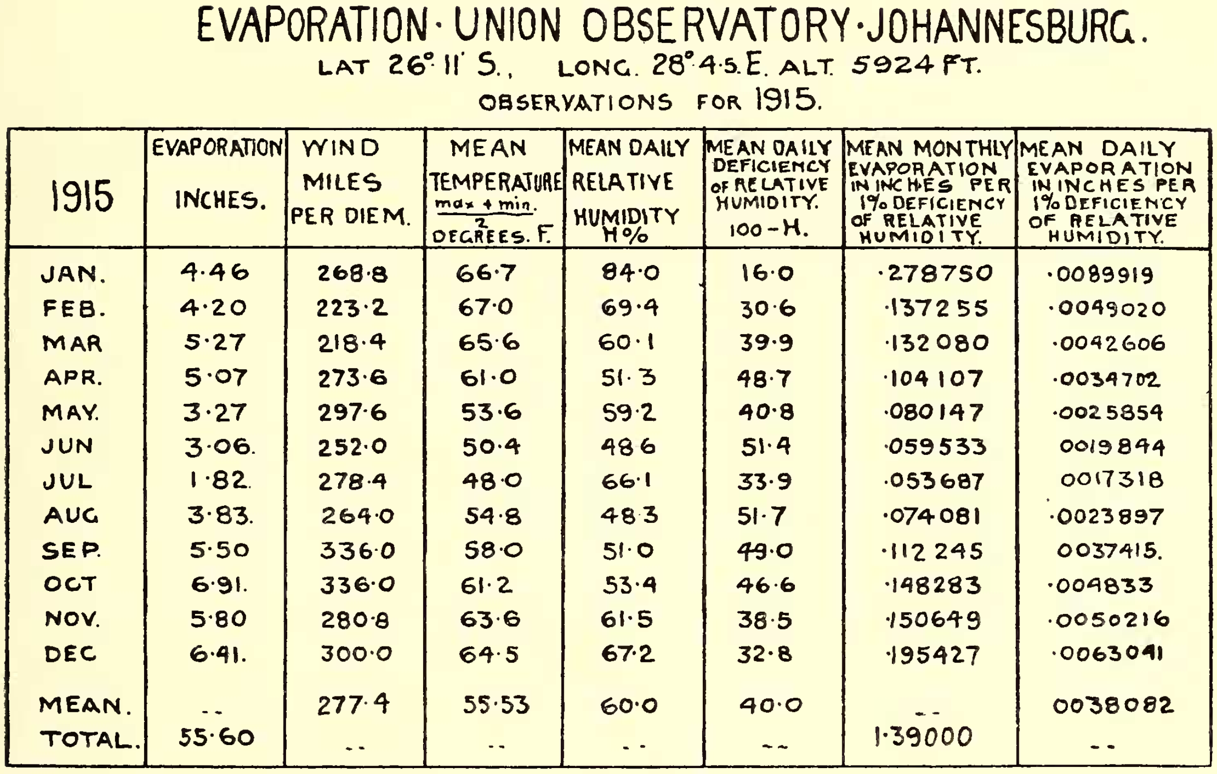
EVAPORATION· UNION OBSERVATORY·JOHANNESBURG

LAT. 26° 11′ S. LONG. 28° 4·5. E, ALT. 5924 FT.

OBSERVATIONS FOR 1914

1914.	EVAPORATION INCHES.	WIND MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{max}+\text{min}}{2}$ DEGREES. F.	MEAN DAILY RELATIVE HUMIDITY H %	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100−H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	6·65	300·0	69·3	63·2	36·8	·180706	·0058292
FEB.	6·43	266·4	67·0	67·6	32·4	·198457	·0070877
MAR.	5·27	240·0	64·8	66·2	33·8	·155917	·0050296
APR.	5·16	247·2	61·9	61·1	38·9	·132648	·0044216
MAY.	3·80	206·4	56·6	56·1	43·9	·086560	·0027923
JUN	3·33	213·6	49·9	53 0	47·0	·070851	·0023617
JUL	4·11	220·8	52·2	38·2	61·8	·066505	0021453
AUG	4·74	266·4	51·2	48·1	51·9	·091329	·0029461
SEP.	7 21	302·4	64·3	41·4	58·6	123038	·0041013
OCT	6·32	288·0	63·7	60·3	39·7	159194	0051358
NOV.	7·63	333·6	62·0	64·2	35·8	·213128	·0071043
DEC	5·47	261·6	66·0	78·8	21·2	·258019	·0083229
MEAN.	..	262·2	60·74	58·18	41·82	...	0043317.
TOTAL.	66·12	...	..	..		1·581062	...

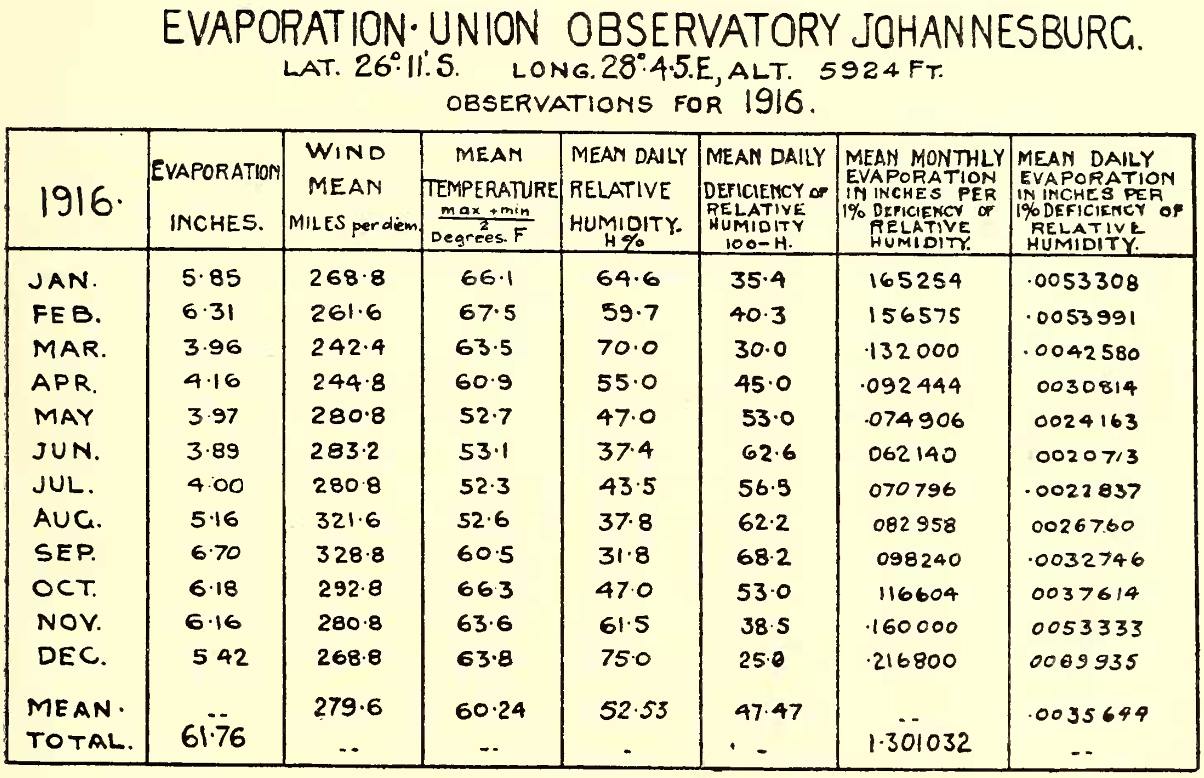
TABLE 9.



EVAPORATION · UNION OBSERVATORY · JOHANNESBURG.
LAT 26° 11′ S., LONG. 28° 4·5 E. ALT. 5924 FT.
OBSERVATIONS FOR 1915.

1915	EVAPORATION INCHES.	WIND MILES PER DIEM.	MEAN TEMPERATURE $\frac{\text{max + min.}}{2}$ DEGREES. F.	MEAN DAILY RELATIVE HUMIDITY H%	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY. 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	4·46	268·8	66·7	84·0	16·0	·278750	·0089919
FEB.	4·20	223·2	67·0	69·4	30·6	·137255	·0049020
MAR	5·27	218·4	65·6	60·1	39·9	·132080	·0042606
APR.	5·07	273·6	61·0	51·3	48·7	·104107	·0034702
MAY.	3·27	297·6	53·6	59·2	40·8	·080147	·0025854
JUN	3·06.	252·0	50·4	48·6	51·4	·059533	0019844
JUL	1·82.	278·4	48·0	66·1	33·9	·053687	0017318
AUG	3·83.	264·0	54·8	48·3	51·7	·074081	·0023897
SEP.	5·50	336·0	58·0	51·0	49·0	·112245	0037415.
OCT	6·91.	336·0	61·2	53·4	46·6	·148283	·004833
NOV.	5·80	280·8	63·6	61·5	38·5	·150649	·0050216
DEC	6·41.	300·0	64·5	67·2	32·8	·195427	·0063041
MEAN.	--	277·4	55·53	60·0	40·0	--	0038082
TOTAL.	55·60	--	--	--	--	1·39000	--

TABLE 10.



EVAPORATION · UNION OBSERVATORY JOHANNESBURG.
LAT. 26° 11′ S. LONG. 28° 4·5 E, ALT. 5924 FT.
OBSERVATIONS FOR 1916.

1916·	EVAPORATION INCHES.	WIND MEAN MILES per diem.	MEAN TEMPERATURE $\frac{\text{max + min}}{2}$ Degrees. F	MEAN DAILY RELATIVE HUMIDITY. H %	MEAN DAILY DEFICIENCY OF RELATIVE HUMIDITY 100 − H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	5·85	268·8	66·1	64·6	35·4	165254	·0053308
FEB.	6·31	261·6	67·5	59·7	40·3	156575	·0053991
MAR.	3·96	242·4	63·5	70·0	30·0	·132000	·0042580
APR.	4·16	244·8	60·9	55·0	45·0	·092444	0030814
MAY	3·97	280·8	52·7	47·0	53·0	·074906	0024163
JUN.	3·89	283·2	53·1	37·4	62·6	062140	0020713
JUL.	4·00	280·8	52·3	43·5	56·5	070796	·0022837
AUG.	5·16	321·6	52·6	37·8	62·2	082958	0026760
SEP.	6·70	328·8	60·5	31·8	68·2	098240	·0032746
OCT.	6·18	292·8	66·3	47·0	53·0	116604	0037614
NOV.	6·16	280·8	63·6	61·5	38·5	·160000	0053333
DEC.	5 42	268·8	63·8	75·0	25·0	·216800	0069935
MEAN·	--	279·6	60·24	52·53	47·47	--	·0035649
TOTAL.	61·76	--	--	-	--	1·301032	--

TABLE 11.

EVAPORATION· UNION OBSERVATORY· JOHANNESBURG·

LAT. 26° 11' S. LONG. 28° 4·5 E, ALT. 5924 FT.

OBSERVATIONS FOR 1917.

1917.	EVAPORATION INCHES	WIND MEAN MILES per diem	MEAN TEMPERATURE $\frac{max + min}{2}$ Degrees. F.	MEAN DAILY RELATIVE HUMIDITY H.%	MEAN DAILY DEFICIENCY - OF RELATIVE HUMIDITY 100 — H.	MEAN MONTHLY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.	MEAN DAILY EVAPORATION IN INCHES PER 1% DEFICIENCY OF RELATIVE HUMIDITY.
JAN.	5·63	256·8	66 6	67·7	32·3	174303	·0056227
FEB.	4·42	271·2	64·1	71·5	28·5	·155088	0055389
MAR.	4·18	247·2	64 3	63·8	36·2	115469	·0037248
APR.	4·33	254·4	57·8	63·5	36·5	·118630	0038268
MAY.	3·81	247·2	54·2	52·7	47 3	080550	·0025984
JUN.	2·90	278·4	49 8	56·6	43·4	066820	·0022273
JUL.	3·09	316·8	47·0	53·8	46·2	066883	0021575
AUG.	3·23	276·0	49 2	63·8	36·2	089226	0028783
SEP	4·55	304·8	56·7	63·8	36·2	125690	0041896
OCT	7·16	304·8	63·7	49·1	50·9	140668	0045377
NOV	6·17	285·6	61·0	72 4	27·6	223551	0074517
DEC.	4·57	244·8	62 6	77 6	22 4	204018	0065812
MEAN.	--	274·0	58·08	63·03	36·97	-	0040047
TOTAL.	54 04	-	-		-	1·461726	- - -

TABLE 12.

KENILWORTH· KIMBERLEY.
MEAN ANNUAL EVAPORATION FOR EACH HOUR PER DIEM.

FROM DR SUTTONS PAPER TO THE SOCIETY FOR ADVANCEMENT OF SCIENCE 1904.

HOUR	MEAN * ANNUAL EVAPORATION INCHES.	MEAN DAILY EVAPORATION INCHES.	MEAN * RELATIVE HUMIDITY H. %	MEAN * TEMPERATURE °Fahr.	MEAN DEFICIENCY OF HUMIDITY 100 — H. %	MEAN ANNUAL EVAPORATION PER 1% OF DEFICIENCY	MEAN DAILY EVAPORATION PER 1% OF DEFICIENCY.
I	1·480	·000405	62·00	55·70	38·00	·03894 inch	·0001066 inch
II	1·474	·000403	64·20	54·55	35 80	·04117	·0001128
III	1·430	000391	66 15	53·50	33·85	·04224	·0001157
IV	1·417	·000 388	67·70	52·60	32·30	·04386	·0001201
V	1·401	·000 383	69·20	51·75	30 ·80	·04548	·0001246
VI	1·485	·000 406	70·75	51·30	29·25	·05076	·0001390
VII	1·759	·000 481	70 00	52·50	30·00	·05863	·0001606
VIII	1·892	·000 518	63·80	56·50	36·20	05226	·0001431
IX	2·051	·000 562	54·60	62·05	45·40	·04517	0001237
X	2·447	000670	47·05	66·95	52·95	·04621	·0001266
XI	3·007	·000823	41 70	70·75	58·30	·05157	·0001413
XII (noon)	3·688	·001010	37·70	73·65	62·30	·05919	0001621
XIII	4·387	·001201	35·85	75·70	64·15	·06838	·0001873
XIV	4·783	·001310	33·20	76·85	66·80	·07160	·0001961
XV	4·803	·001315	32·65	77·20	67·35	·07131	·0001953
XVI	4·388	·001202	33 20	76·65	66·80	·06568	·0001799
XVII	3·710	·001016	36·40	74·40	63·60	·05833	·0001598
XVIII	2·854	000781	41·85	70·45	58·15	·04907	·0001344
XIX	2·245	·000615	46·95	66·40	53·05	·04232	·0001159
XX	1·935	·000530	50·55	63·50	49·45	·03913	·0001072
XXI	1·819	·000498	53·00	61·45	47·00	·03870	0001060
XXII	1·731	·000474	55·30	59·70	44·70	·03872	·0001061
XXIII	1·717	·000470	57·55	58·15	42·45	·04044	·0001108
XXIV	1·529	000419	59·75	56·85	40·25	·03798	·0001040

NOTE: Dr Sutton's data marked * *thus.*